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North Korea's Nuclear Weapons: Latest Developments

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Summary

On October 9, 2006, North Korea announced it conducted a nuclear test. It is not yet clear whether North Korea achieved a nuclear yield and if so, how big. North Korea ended an eight-year freeze on its plutonium production program in 2002, expelling international inspectors and restarting facilities. Whereas many believed North Korea might have had enough plutonium (Pu) for one or two weapons in then, North Korea may now have enough Pu for six or eight more weapons. In 2005, North Korea announced it had nuclear weapons, but rejoined the Six-Party Talks in July and agreed to abandon its nuclear weapons program in September 2005. The failure of the talks has allowed North Korea to continue to produce fissile material for nuclear weapons. The United States and other countries have condemned the North Korean nuclear test and called for sanctions. This report will be updated as needed.

Background

In the early1980s, U.S. satellites tracked a growing indigenous nuclear program in North Korea. A small nuclear reactor at Yongbyon (5MWe), capable of producing about 6kg of plutonium per year, began operating in 1986.[1] Later that year, U.S. satellites detected high explosives testing and a new plant to separate plutonium. In addition, construction of two larger reactors (50MWe at Yongbyon and 200MWe at Taechon) added to evidence of a serious clandestine effort. Although North Korea had joined the Nuclear Nonproliferation Treaty in 1985, the safeguards inspections that began only in 1992 raised questions about how much plutonium North Korea had produced covertly. In 1994, North Korea pledged, under the Agreed Framework with the United States, to freeze its plutonium programs and eventually dismantle them in return for several kinds

[1] 5MWe is a power rating for the reactor, indicating that it produces 5 million watts of electricity per day (very small). Reactors are also described in terms of million watts of heat (MW thermal).

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of assistance.[2] At that time, Western intelligence agencies estimated that North Korea had separated enough plutonium for one or two bombs; other sources estimated four to five bombs.

Weapons Production Milestones

Acquiring fissile material — plutonium-239 or highly enriched uranium (HEU) — is the key hurdle in nuclear weapons development.[3] Producing these two materials is technically challenging; in comparison, many experts believe weaponization to be relatively easy.[4] North Korea has industrial-scale uranium mining, and plants for milling, refining, and converting uranium; it also has a fuel fabrication plant, a nuclear reactor, and a reprocessing plant — in short, everything needed to produce Pu-239. In its nuclear reactor, North Korea uses magnox fuel — natural uranium (>99%U-238) metal, wrapped in magnesium-alloy cladding. About 8000 fuel rods constitute a fuel core for the reactor.

When irradiated in a reactor, natural uranium fuel absorbs a neutron and then decays into plutonium (Pu-239). Fuel that remains in the reactor for a long time becomes contaminated by the isotope Pu-240, which can "poison" the functioning of a nuclear weapon.[5] Spent or irradiated fuel, which poses radiological hazards, must cool after removal from the reactor. The cooling phase, estimated by some at five months, is proportional to the fuel burn-up. Reprocessing to separate plutonium from waste products and uranium is the next step. North Korea uses a PUREX separation process, like the United States. After shearing off the fuel cladding, the fuel is dissolved in nitric acid. Components (plutonium, uranium, waste) of the fuel are separated into different streams using organic solvents. In small quantities, separation can be done in hot cells, but larger quantities require significant shielding to prevent deadly exposure to radiation.[6]

Most experts agree that North Korea has mastered the engineering requirements of plutonium production. Its 5MWe nuclear reactor operated from 1986 to 1994, restarting in January 2003. North Korean officials claimed to have separated plutonium in hot cells and tested the reprocessing plant in 1990, and to have reprocessed all 8000 fuel rods from the 5MWe reactor between January and June 2003. The January 2004 unofficial U.S. delegation reported that "All indications from the display in the control room are that the reactor is operating smoothly now....However, we have no way of assessing independently how well the reactor has operated during the past year."[7] The same delegation reported that the reprocessing "facility appeared in good repair," in contrast to a 1992 IAEA

[2] See CRS Report RL33590, *North Korea's Nuclear Weapons Program*, by Larry Niksch.

[3] Highly enriched uranium (HEU) has 20% or more U-235 isotope; weapons-grade uranium is 90% or more U-235.

[4] While the physical principles of weaponization are well-known, producing a weapon with high reliability, effectiveness and efficiency without testing holds significant challenges.

[5] Plutonium that stays in a reactor for a long time (reactor-grade, with high "burn-up") contains about 20% Pu-240; weapons-grade plutonium contains less than 7% Pu-240.

[6] Hot cells are heavily shielded rooms with remote handling equipment for working with irradiated materials.

[7] Siegfried Hecker, Jan. 21, 2004, testimony before Senate Foreign Relations Committee.

assessment of the reprocessing plant as "extremely primitive." In the end, however, significant growth in North Korea's arsenal depends on the completion of the two larger reactors and progress in the reported uranium enrichment program.

In January 2004, North Korean officials showed an unofficial U.S. delegation alloyed "scrap" from a plutonium (Pu) casting operation. Alloying plutonium with other materials is "common in plutonium metallurgy to retain the delta-phase of plutonium, which makes it easier to cast and shape" (two steps in weapons production).[8] Dr. Siegfried Hecker, a delegation member, assessed that the stated density of the material was consistent with plutonium alloyed with gallium or aluminum. If so, this could indicate a certain sophistication in North Korea's handling of Pu metal, but Hecker could not confirm that the metal was indeed plutonium, that it was alloyed, or that it was from the most recent reprocessing campaign, without conducting actual tests of the material.

There is virtually no information on North Korean nuclear weapons design. The simplest, gun-type design requires no testing, but can only be made with HEU, not plutonium. Implosion devices, which use sophisticated lenses of high explosives to compress plutonium, are more likely to require testing. Some observers believe that North Korean testing of high explosives with particular compression patterns in the 1980s indicates the ability to manufacture an implosion device.[9] The October 9, 2006 North Korean test appears to be inconclusive thus far; experts vary on whether North Korea achieved a nuclear yield. Seismic monitors detected an explosion equivalent to an earthquake of about 4.2 on the Richter scale; some experts have translated that into a one kiloton or less explosion. The French foreign minister suggested there was no nuclear yield at all, while others declined to draw conclusions. More information could be needed to determine the magnitude, if any, of a nuclear yield.

One uncertainty is whether Pakistani scientist A.Q. Khan provided North Korea the same Chinese-origin nuclear weapon design he provided to Libya. If so, North Korea might develop a reliable warhead for ballistic missiles without testing. Such a warhead needs to be small, light and robust enough to tolerate the extreme conditions encountered through a ballistic trajectory. Although former DIA Director Jacoby told the Senate Armed Services Committee in April 2005 that North Korea had the capability to arm a missile with a nuclear device, Pentagon officials later backtracked from that assessment.

Estimating Nuclear Material Production

Most estimates of nuclear weapon stockpiles are based on estimated fissile material production. Factors in plutonium production include the average power level of the reactor; days of operation; how much of the fuel is reprocessed and how quickly, and how much plutonium is lost in production processes. According to North Korea, the 5MWe reactor performed poorly early on, unevenly irradiating the rods. There is no data on the reactor's current performance or the reprocessing facility's efficiency. North Korea told the IAEA that during the 1990 "hot test," it lost almost 30% of the plutonium in the waste

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[8] Hecker, Jan. 21, 2004 testimony before SFRC.

[9] Don Oberdorfer, *The Two Koreas*, (MA: Addison-Wesley, 1997), p. 250.

streams.[10] A key consideration is whether or not the reprocessing plant can run continuously, since frequent shutdowns can lead to plutonium losses. According to North Korean officials in January 2004, the plant annual throughput is 110 tons of spent fuel, about twice the fuel load of the 5MWe reactor. A final factor in assessing how many weapons North Korea can produce is whether North Korea's technical sophistication enables it to use more or less material than the international standards of 8kg of Pu and 25kg for HEU per weapon. North Korea's abilities here are unknown.

What Does North Korea Have Now?

Secretary of State Powell stated in December 2002 that "We now believe they [North Koreans] have a couple of nuclear weapons and have had them for years."[11] On February 10, 2005, North Korea announced that it had manufactured "nukes" for self-defense and that it would bolster its nuclear weapons arsenal.[12] In June 2005, Vice Foreign Minister Kim Gye Gwan told ABC News that "We have enough nuclear bombs to defend against a U.S. attack. As for specifically how many we have, that is a secret." Kim also said North Korea was building more bombs and when asked about delivery systems, said "our scientists have the knowledge, comparable to other scientists around the world."[13] Some observers interpreted this to mean that North Korea can mate nuclear warheads to missiles. Some Members of Congress interpreted CIA Director Porter Goss's statements in March 2005 on a "range" of nuclear weapon estimates to confirm that North Korea's arsenal has multiplied.[14] In December 2005, angered by U.S. criticism of its human rights record and financial sanctions, the North Korean foreign ministry stated that it would "increase [its] self-reliant national defense capacity, including nuclear deterrent."[15] In October 2006, North Korea's Foreign Ministry said that the government would conduct a nuclear test when safety was guaranteed, and that "nuclear weapons will serve as reliable war deterrent."

Has North Korea reprocessed the existing spent fuel?. On July 13, 2003, North Korean officials told U.S. officials in New York that they had completed reprocessing the 8000 fuel rods on June 30.[16] On January 8, 2004, North Korean officials told an unofficial U.S. delegation that the reprocessing campaign began in mid-January 2003 and ended at the end of June 2003. In all, they reportedly reprocessed 50 tons of spent fuel in less than six months, which tracks with earlier estimates that North Korea could reprocess about 11 tons/month, roughly enough plutonium for one bomb per month.

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[10] David Albright and Kevin O'Neill, editors, *Solving the North Korean Nuclear Puzzle*, ISIS Report, ISIS Press, 2000, p. 88.

[11] Transcript of Dec. 29, 2002 *Meet the Press*.

[12] "North Korea Says It Has Nuclear Weapons and Rejects Talks," *New York Times*, Feb. 10, 2005.

[13] "N. Korea Building Bombs, Its Envoy Says," *Los Angeles Times*, June 9, 2005.

[14] Carl Levin and Hillary Clinton, "North Korea's Rising Urgency," *Washington Post*, July 5, 2005.

[15] "N. Korea: Nuclear Program to Expand," *Philadelphia Inquirer*, Dec. 20, 2005.

[16] "North Korea Says It Has Made Fuel For Atom Bombs," *New York Times*, July 15, 2003.

An unofficial U.S. delegation in January 2004 concluded that the spent fuel pond no longer held the 8,000 fuel rods and surmised that they could have been moved to another storage location, but not without significant health and safety risks. The delegation was not allowed to visit the Dry Storage Building, where the fuel rods likely would have been stored before reprocessing. The delegation also did not visit waste facilities. Reprocessing the 8,000 fuel rods from the 5MWe reactor would yield between 25 and 30kg of plutonium, perhaps for five or six weapons, but the exact amount of plutonium that might have been reprocessed is unknown. In 2004, North Korean officials stated that the reprocessing campaign was conducted continuously (four six-hour shifts). U.S. efforts to detect Krypton-85 (a by-product of reprocessing) reportedly suggested that some reprocessing had taken place, but were largely inconclusive.

Adding to the Arsenal

Make New Plutonium in 5MWe Reactor. On February 6, 2003, North Korean officials announced that the 5MWe reactor was operating, and commercial satellite photography confirmed activity in March. In January 2004, North Korean officials told U.S. visitors that the reactor was now operating smoothly at 100% of its rated power. The U.S. visitors noted that the display in the reactor control room and steam plumes from the cooling towers confirmed operation, but that there was no way of knowing how it had operated over the last year. In April 2005, the reactor was shut down, and on May 11, 2005, North Korean officials stated they harvested fuel rods for weapons.[17] According to commercial satellite images, the reactor resumed operations in August 2005.[18]

A common estimate is that the reactor generates 6 kg of Pu per year, roughly one bomb per year, but the reactor would likely be operated for several years before fuel is withdrawn. One estimate is that the reactor held between 10 and 15 kg Pu in April 2005, and that North Korea could have reprocessed all the fuel by mid-2006.[19] From 2006 to 2006, the reactor could have produced another 6 kg of Pu; in total, there could be enough separated plutonium for another four weapons.

Complete Other Reactors. The reactors at Yongbyon (50MWe) and Taechon (200MWe) are likely several years from completion. U.S. visitors in January 2004 saw heavy corrosion and cracks in concrete building structures at Yongbyon, reporting that the reactor building "looks in a terrible state of repair."[20] The CIA estimates that the two reactors could generate about 275kg of plutonium per year.[21] In August 2005, another unofficial U.S. delegation to Pyongyang was told by North Korean officials that they

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[17] "North Koreans Claim to Extract Fuel for Nuclear Weapons," *New York Times*, May 12, 2005.

[18] David Albright and Paul Brannan, "The North Korean Plutonium Stock Mid-2006," Institute for Science and International Security, June 26, 2006, p. 3.

[19] Ibid.

[20] Hecker Jan. 21, 2004 testimony before SRFC.

[21] CIA unclassified point paper distributed to Congressional staff on Nov. 19, 2002.

planned to finish building the 50MWe reactor within two years. Commercial satellite images in 2005 and 2006 show little progress.[22]

Produce Highly Enriched Uranium for Weapons. A 2002 unclassified CIA working paper on North Korea's nuclear weapons and uranium enrichment estimated that North Korea "is constructing a plant that could produce enough weapons-grade uranium for two or more nuclear weapons per year when fully operational — which could be as soon as mid-decade."[23] Such a plant would need to produce more than 50kg of HEU per year, requiring cascades of thousands of centrifuges. The paper noted that in 2001, North Korea "began seeking centrifuge-related materials in large quantities." The CIA has not released any other unclassified statements on North Korea's enrichment capabilities since 2002. Pakistan's A.Q. Khan probably offered the same P-2-design centrifuges to North Korea as he did to Libya and Iran, but since the United States has not pressed for access to Khan, this is impossible to verify.

Centrifuge enrichment of uranium poses significant technical challenges. Nonetheless, such a program may offer a few advantages to North Korea: such plants are difficult to locate and target, making them less vulnerable to military strikes than reactors or reprocessing plants. HEU also could give the North Koreans the option of producing either simpler weapons (gun-assembly type) or more sophisticated weapons (using composite pits or boosted fission techniques). Also, an HEU program could be politically useful as a bargaining chip in negotiations.

How to Verify North Korean Claims?

Information about North Korea's nuclear weapons production has depended on remote monitoring and defector information, with mixed results. Satellite images correctly indicated the start-up of the 5MWe reactor, but gave no details about its operations. Satellites also detected trucks at Yongbyon in late January 2003, but could not confirm the movement of spent fuel to the reprocessing plant;[24] imagery reportedly detected activity at the reprocessing plant in April 2003, but could not confirm large-scale reprocessing;[25] and, satellite imagery could not peer into an empty spent fuel pond, which was shown to U.S. visitors in January 2004. Even U.S. scientists visiting Pyongyang in January 2004 could not confirm North Korean claims of having reprocessed the spent fuel or that the material shown was in fact plutonium. Verifying those claims would require greater access to the material and North Korean cooperation. This is particularly true in the case of uranium enrichment; U.S. intelligence officials have said they do not know where the uranium program is. According to one senior Administration official, the North Koreans have "got to give it up. That's how the Libyans did it."[26] With respect to the nuclear test, more data is needed to draw conclusions about North Korea's weapons.

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[22] Albright and Brannan, "The North Korean Plutonium Stock Mid-2006," p. 4.

[23] CIA unclassified point paper.

[24] "Reactor Restarted, North Korea Says," *Washington Post*, Feb. 6, 2003.

[25] "US Suspects North Korea Moved Ahead on Weapons," *New York Times*, May 6, 2003.

[26] "U.S. Offers North Korea Evidence That Nuclear Secrets Came From Pakistani's Network," *New York Times*, July 29, 2005.